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WEATHER AND CIRCULATION OF JUNE 1972

A Month With Two Major Flood Disasters

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1. MEAN CIRCULATION

The midlatitude zonal westerlies continued to be stronger than normal during June, as they have for most of the year so far. As during the previous month (Dickson 1972), the 700-mb flow was not strong over the United States, but was anomalously strong over the oceans, where deep Aleutian and Icelandic Lows were observed with stronger than normal midocean ridges (figs. 1, 2). The gradient over the north Atlantic was especially remarkable, as 700-mb heights were 118 m above normal east of Newfoundland but 115 m below normal between Scotland and Iceland. The peak 700-mb mean wind speed was 19 m/s, which is 12 m/s above normal at that location just southeast of the tip of Greenland (fig. 4). The mean polar Low persisted with greater than normal vigor near Baffin Island.

The height anomaly change from May to June (fig. 3) showed a relative strengthening of the westerly gradient over northern portions of the two oceans. This was accomplished by the building of the subtropical ridges into midlatitudes while the normal early summer weakening of the Aleutian and Icelandic Lows failed to occur (cf. fig. 1 with fig. 1 of Dickson 1972).

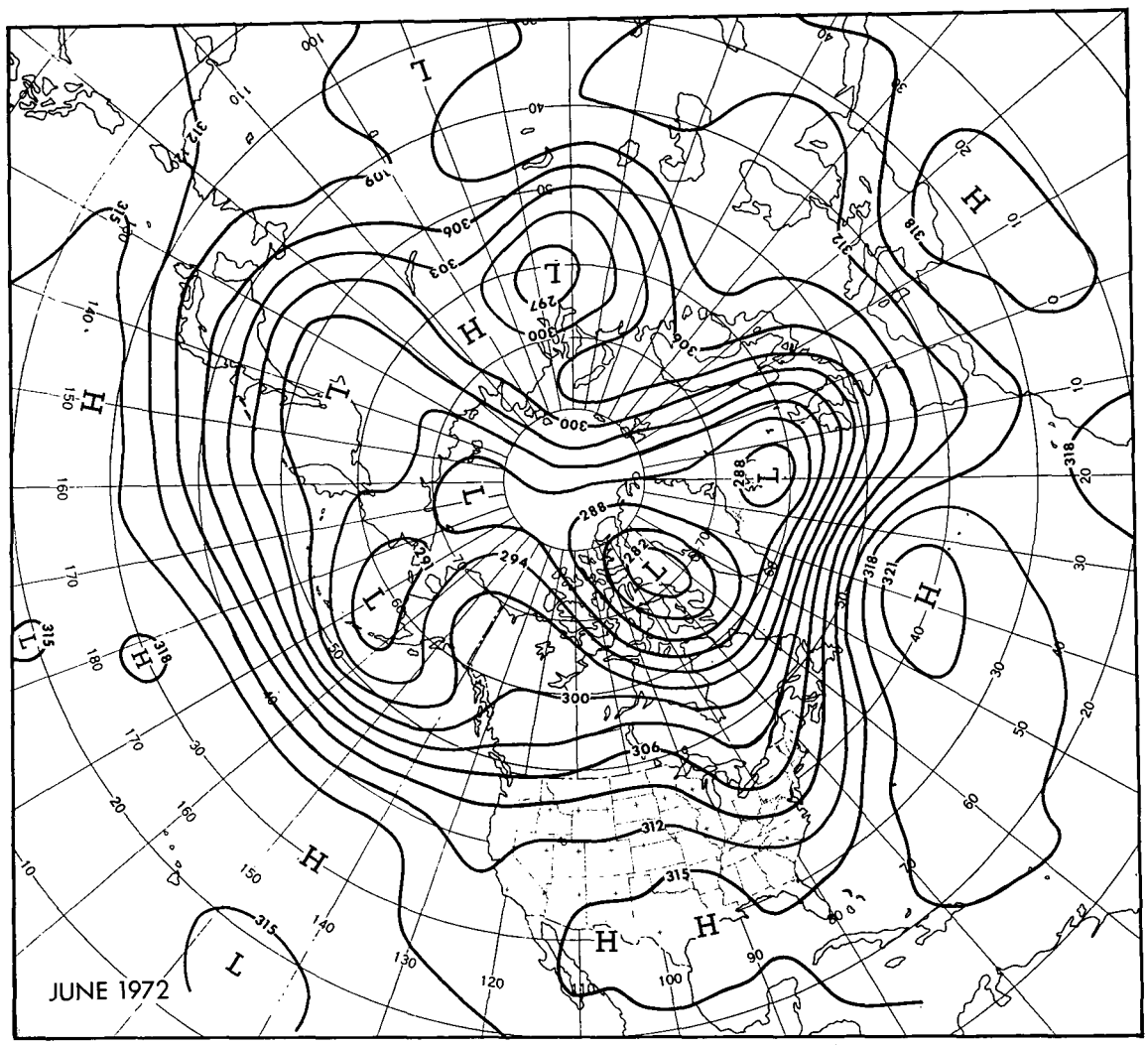


FIGURE 1.—Mean 700-mb contours in dekameters (dam) for June 1972.

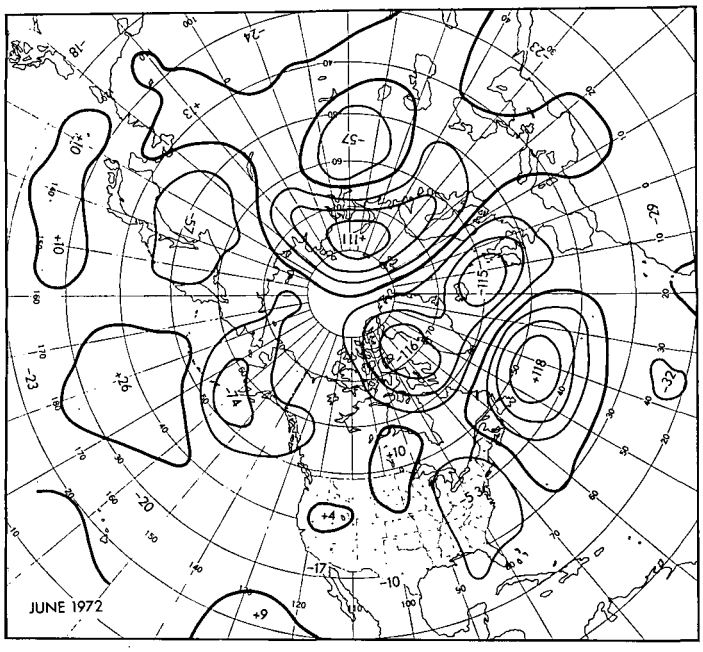


FIGURE 2.—Departure from normal of mean 700-mb height (m) for June 1972.

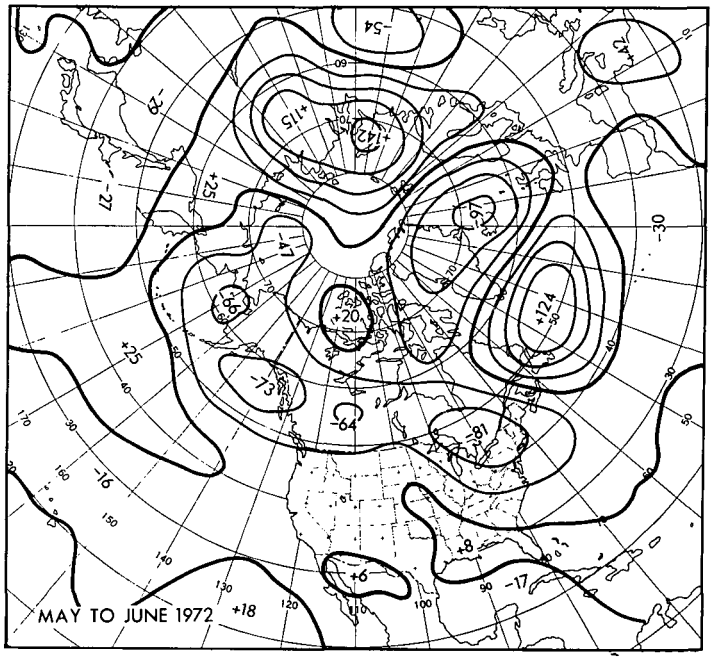


FIGURE 3.—Mean 700-mb height anomaly change (m) from May to June 1972.

The greatest circulation change from May to June occurred over Asia, where the growth of a strong blocking ridge extending from Scandinavia across Novaya Zemlya to the Taymyr Peninsula deflected the remains of what had been the Asian portion of the polar Low quite far south into Russia (figs. 1–3). The collapse of all but a remnant of May's strong blocking over southern Canada was indicated by a band of strong, negative, height anomaly change across that area (fig. 3). A deep, full-latitude trough was located near the east coast of North America.

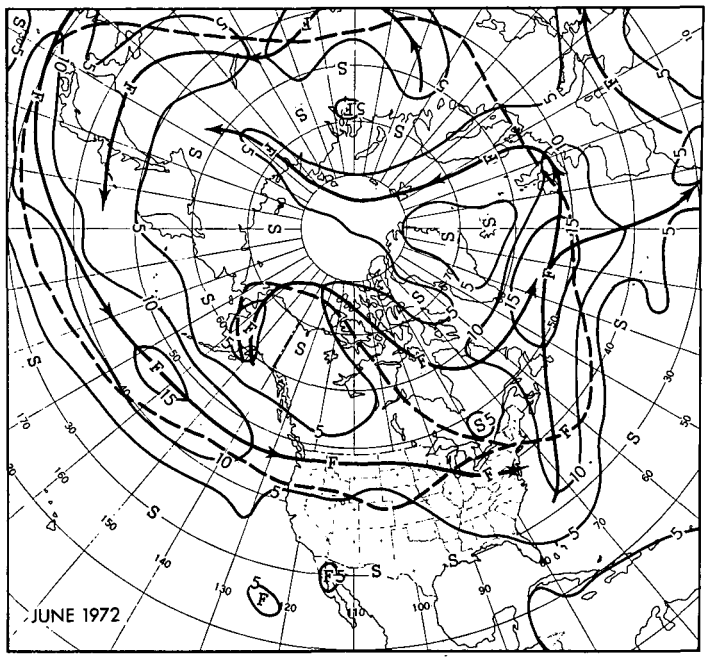


FIGURE 4.—Mean 700-mb geostrophic wind speed (m/s) for June 1972. Solid arrows show the observed axes of maximum wind speed, and dashed lines show the normal June positions. Isotachs are at intervals of 5 m/s.

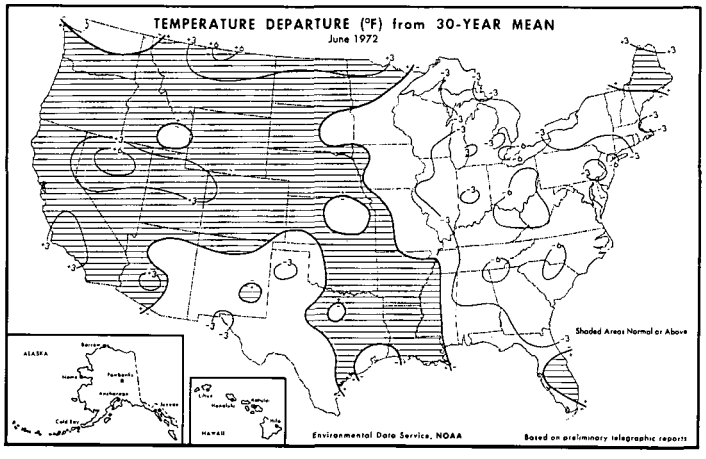


FIGURE 5.—Departure from normal of average surface temperature (°F) for June 1972 (from Environmental Data Service and Statistical Reporting Service 1972).

The 700-mb wind speed maxima, which were single and much stronger than normal over the oceans, became weaker and split into two or more branches over the continents (fig. 4). In most areas, the 700-mb wind speed maxima were located somewhat north of their normal positions.

2. TEMPERATURE

June temperatures were generally lower than normal over the eastern half of the country and above normal from the Northern and Central Great Plains westward to the Pacific coast (fig. 5). The temperature anomaly pattern was reasonably related to the height anomaly pattern (fig. 2). The lowest temperatures relative to normal were ob-

TABLE 1.—*Monthly mean temperature records established in June 1972*

Location	Temp.	Anomaly	Remarks
	(°F)	(°F)	
Lexington, Ky.	67. 6	−6. 0	Coldest June since 1928
Cleveland, Ohio	62. 7	−5. 1	2d coldest June on record
Youngstown, Ohio	60. 8	−6. 3	Coldest June on record
Cincinnati, Ohio	66. 9	−6. 5	Do.
Erie, Pa.	59. 6	−4. 7	Do.
Parkersburg, W. Va.	66. 1	−6. 5	Do.
Greensboro, N.C.	68. 7	−6. 1	Do.
Wilmington, N.C.	72. 7	−5. 0	Do.
Charlotte, N.C.	71. 3	−5. 8	Coldest June since 1884; 2d coldest June on record
Long Beach, Calif.	70. 7	+3. 2	Warmest June on record (1941)
Salt Lake City, Utah	71. 9	+4. 5	3d warmest June on record (1928)
Do.	58. 3	+7. 3	Warmest June mean minimum

served close to the negative monthly mean 700-mb height anomaly center (53 m below normal). A record late-season cold snap that produced frost in some places and persistent low maxima due to the excessive rains and cloudiness from tropical storm Agnes combined to help produce the coldest June on record at several stations in the Ohio Valley, Central Appalachian Mountains, and Piedmont area (table 1).

Highest temperatures relative to normal were observed in Montana, where the remains of the previous month's blocking gave an anomalous southerly wind component, and over the Great Basin where considerable ridging had been occurring. Temperatures remained slightly lower in the Southern Great Plains and Rio Grande Valley area where the 700-mb monthly mean heights were below normal and cloudiness and precipitation were generally above normal.

3. PRECIPITATION

The June precipitation pattern showed two extensive areas of more than twice normal rainfall (fig. 6). The above-normal precipitation in the southwestern United States for the most part represented a great blessing, as the first substantial rains since last December fell in some localities, ending the longest rainless spell on record and relieving drought conditions considerably. It was the wettest June on record at several normally dry stations (table 2), although in some places, the first half year of 1972 was still the driest such period on record due to complete failure of the winter and spring rains. The June rains were more of the summer type, which usually have their onset around the first of July.

The large area of heavier than normal precipitation centered over Pennsylvania was due primarily to torrential rains from tropical storm Agnes, the first tropical storm of the season, which had been only a minimal hurricane for a day or so while crossing the northeastern Gulf of Mexico. Some wind and tide damage was done along the west

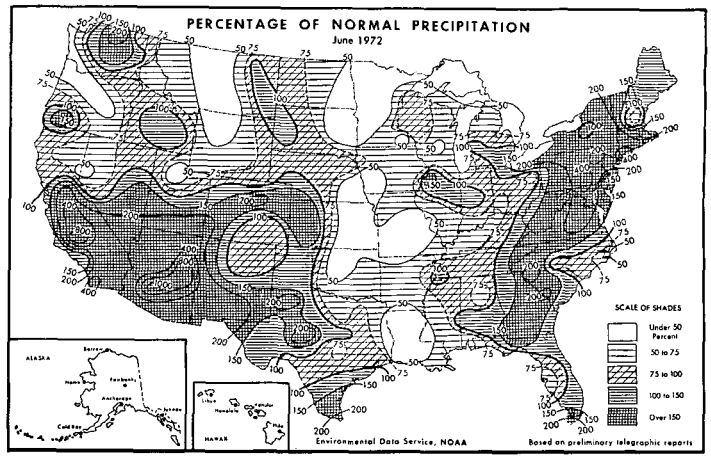


FIGURE 6.—Percentage of normal precipitation for June 1972 (from Environmental Data Service and Statistical Reporting Service 1972).

TABLE 2.—*Precipitation records established in June 1972*

Location	Amount	Anomaly	Remarks
	(in.)	(in.)	
Greensboro, N.C.	4. 91		Greatest June 24-hr total
Washington, D.C.	11. 53	+8. 96	Wettest June
Do.	6. 11		Greatest June 24-hr total
Cleveland, Ohio	9. 06	+5. 63	2d wettest June
Do.	4. 00		Greatest June 24-hr total
Erie, Pa.	7. 50	+4. 45	2d wettest June
Harrisburg, Pa.	18. 55	+15. 13	Wettest month
Do.	12. 55		Greatest 24-hr total
Allentown, Pa.	8. 58	+4. 51	2d wettest June
Syracuse, N.Y.	12. 30	+9. 34	2d wettest June and 2d wettest month
Bridgeport, Conn.	17. 70	+14. 30	Wettest month
Do.	6. 89		Greatest 24-hr total
Hartford, Conn.	9. 66	+5. 96	Wettest June
Do.	35. 61		Wettest 1st 6 mo
Burlington, Vt.	2. 60		Greatest 24-hr total
Worcester, Mass.	9. 25	+5. 41	Wettest June
Providence, R.I.	6. 83	+4. 07	2d wettest June
Key West, Fla.	14. 43	+10. 46	Wettest June
Winslow, Ariz.	3. 22	+2. 96	Do.
Phoenix, Ariz.	1. 70	+1. 61	Do.
Yuma, Ariz.	0. 27	+0. 26	2d wettest June and wettest since 1912
Tucson, Ariz.	0. 68	+0. 39	9 Days with measurable precip., new June record
San Diego, Calif.	0. 38	+0. 33	June wetter than normal,
Do.	0. 67		but driest 1st 6 mo (Jan.–June)
San Francisco, Calif.	4. 86		Driest 1st 6 mo (Jan.–June)
Red Bluff, Calif.	–	–	Driest season (July–June) on record; 47 percent normal
Omaha, Nebr.	1. 03	−3. 50	4th driest June, driest in 39 yr
Fargo, N. Dak.	0. 58	−2. 46	Driest June since 1936
Rochester, Minn.	1. 11	−3. 35	3d driest June

coast of Florida and in the Florida Panhandle near landfall, but by far the worst damage from Agnes was due to flash floods of small streams and extensive flooding of

record or near-record proportions along nearly every major river having its headwaters in the Central Appalachian Mountains.

Many cities with long records reported their wettest June or wettest month on record (table 2), and the James, Appomattox, and Rappahannock Rivers in Virginia and the Susquehanna River in Pennsylvania all had record flood crests. The crest on the Potomac River just missed being a record by a few feet at Washington, D.C., since it coincided with low tide. Overall, the floods from Agnes' rains were among the most extensive in area and cost (probably at least $1½ billion by preliminary estimate) of any in the history of the United States. More than 100 people died from drowning and flood-related accidents in spite of generally good warnings.

A flash-flood disaster with a death toll of around 200 occurred earlier in the month in the Black Hills of South Dakota from a more localized severe-thunderstorm pattern. Casualties were high because the torrential rains and floods struck at night, and many people did not hear the warnings. The severity of the flood was compounded by the failure of a dam.

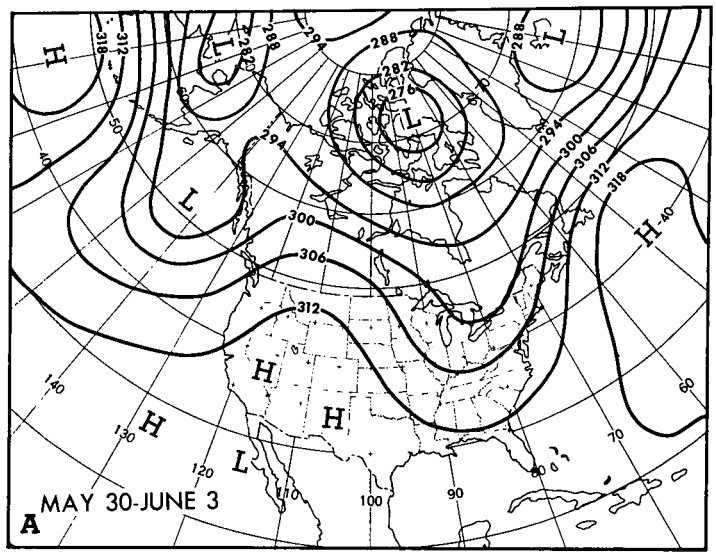
Only the middle third of the Nation had substantially subnormal precipitation during June (fig. 6). A few stations in the North Central States reported one of their driest Junes on record (table 2). The remains of the previous month's blocking ridge and a northerly anomalous component of 700-mb flow (fig. 2) probably reduced the amount of moist southerly air reaching the area from the Gulf of Mexico.

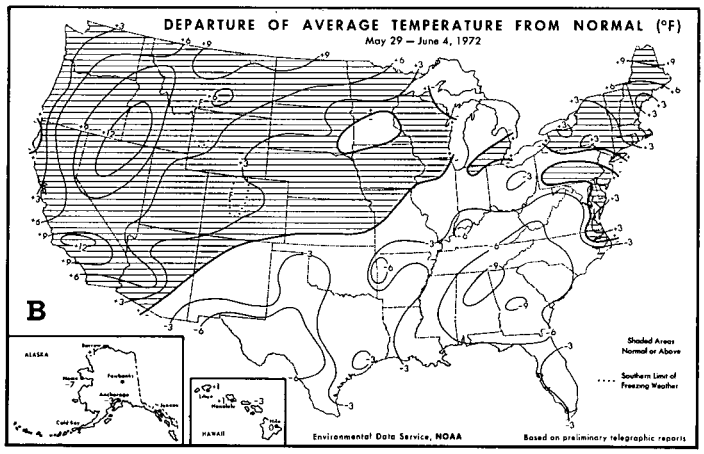
4. WEEKLY WEATHER AND CIRCULATION

May 29–June 4

The circulation at the beginning of June consisted of an amplified wave pattern with troughs over the eastern Pacific and eastern North America while strong ridges were located south of the Aleutians, over the Rocky Mountains, and in the western Atlantic (fig. 7A). Rapid warming occurred under the western ridge, but the eastern trough was associated with cloudiness and rather heavy precipitation. Early in the week, an unusually cold air mass from Canada was advected southeastward, followed by a strong warming trend in the Northern Great Plains as warm air generated by the western ridge began to move eastward.

For the week as a whole, temperatures averaged more than 12°F above normal in the Great Basin, but lingering cold kept average readings as much as 10°F below normal in parts of the Southeast (fig. 7B). The Northeast was generally warm but quite wet under the influence of southwesterly flow ahead of the trough (fig. 7C). Heavy showers and thundershowers also fell in eastern Florida and over parts of the Great Plains. Showers also broke out in parts of Arizona, Nevada, and California, where there had been little or no precipitation in the past 5 mo.





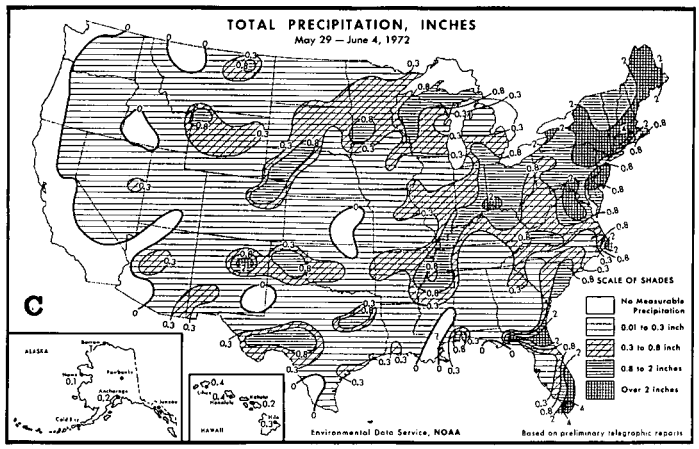
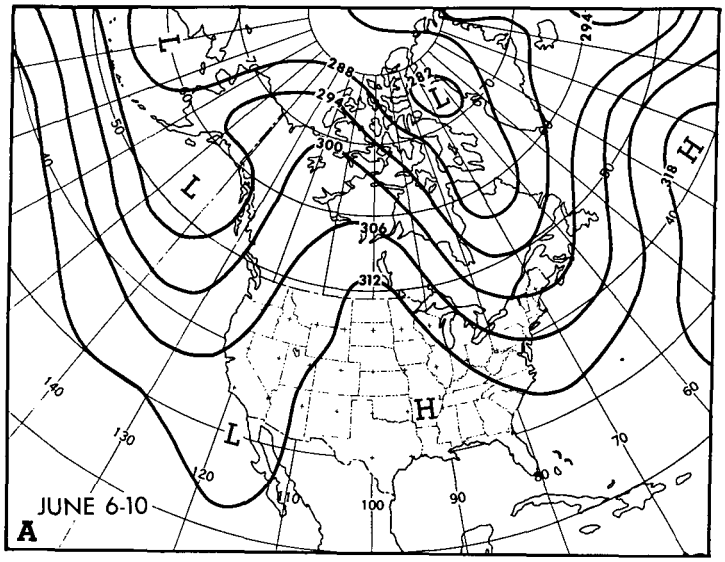


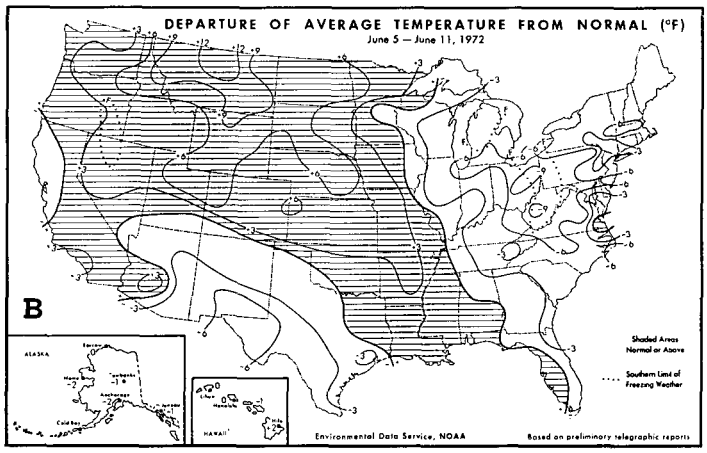
FIGURE 7.—(A) mean 700-mb contours (dam) for May 30–June 3, 1972; (B) departure from normal of average surface temperature (°F); and (C) total precipitation (in.) for week of May 29–June 4, 1972 (from Environmental Data Service and Statistical Reporting Service 1972).

June 5–11

Flattening of the ridge south of the Aleutians led to progression of the eastern Pacific trough to a position just off the west coast. The Rocky Mountain high-pressure ridge and eastern North American trough amplified and underwent smaller eastward displacements to the Great Plains and east coast (fig. 8A).

In line with the progression of the 700-mb circulation features, the temperature anomaly pattern also showed some eastward displacement although the Great Basin





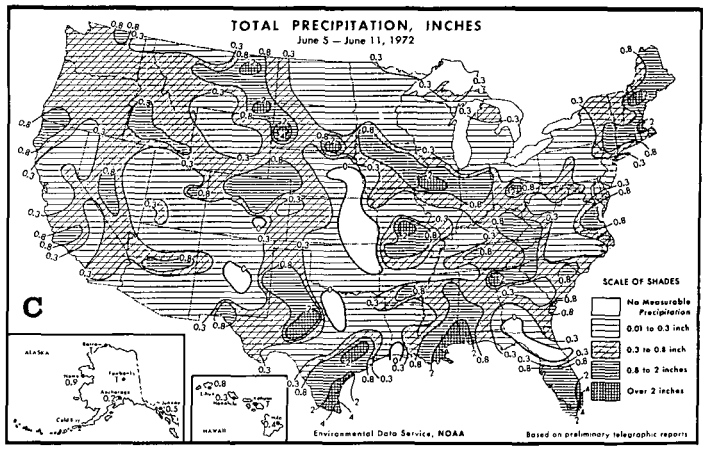


FIGURE 8.—Same as figure 7, (A) for June 6–10, 1972; (B) and (C) for week of June 5–11, 1972.

remained warmer than normal. The greatest anomaly of more than 12°F above normal was located over northern Montana (fig. 8B). The southern and central Mississippi Valley warmed under the influence of the ridge, but the eastern third of the United States remained cool as northwesterly flow continued to bring air masses of Canadian origin into the region. Over the weekend, an unusually cold High from the still ice-covered Hudson Bay area pushed southeastward across the Great Lakes area, setting numerous records for late-season and June cold (table 3).

TABLE 3.—*Monthly and seasonal records for cold established during June 1972*

Location	Temperature	Date	Remarks
	(°F)		
Duluth, Minn.	27	10	Lowest observed in June
Do.	35	17	Lowest so late in season
Madison, Wisc.	31	10	Lowest observed in June
Dubuque, Iowa	36	11	Do.
Muskegon, Mich.	31	11	Do.
Grand Rapids, Mich.	33	11	Do.
Lansing, Mich.	32	11	Lowest so late in season
Fort Wayne, Ind.	39	11	Do.
South Bend, Ind.	35	11	Equaled June lowest
Dayton, Ohio	40	11	Do.
Cincinnati, Ohio	39	11	Lowest observed in June
Columbus, Ohio	35	11	Do.
Cleveland, Ohio	31	11	Do.
Akron, Ohio	32	11	Do.
Youngstown, Ohio	30	11	Do.
Charleston, W. Va.	33	11	Do.
Parkersburg, W. Va.	36	11	Do.
Elkins, W. Va.	29	11	Equaled June lowest
Do.	35	12	Lowest so late in season
Erie, Pa.	32	11	Lowest observed in June
Pittsburgh, Pa.	34	11	Do.
Avoca, Pa.	34	11	Do.
Allentown, Pa.	39	11	Equaled June lowest
Philadelphia, Pa.	44	11	Do.
Baltimore, Md.	40	11	Lowest observed in June
Wilmington, Del.	41	11	Lowest so late in season
Binghamton, N.Y.	35	11	Lowest observed in June
Portland, Maine	37	12	Equaled lowest so late in season
Concord, N.H.	30	12	Lowest observed in June
Bridgeport, Conn.	46	12	Lowest so late in season
Raleigh, N.C.	43	12	Equaled June lowest
Charlotte, N.C.	45	12	Do.
Greensboro, N.C.	42	12	Do.
Cape Hatteras, N.C.	45	12	Do.
Wilmington, N.C.	49	12	Do.
Columbia, S.C.	46	12	Lowest observed in June

Several localities had freezing temperatures and damaging frost.

Under the influence of marked southerly flow between the west coast trough and the Great Plains ridge, extensive areas of precipitation broke out over the whole western part of the country, including the area of severe drought in the Southwest (figs. 8A, 8C). Phoenix, Ariz., reported its first measureable rain in 160 days on June 7. This was the beginning of what was to become the wettest June on record, following the longest rainless period on record.

Some of the moisture contributing to the western rains came from the remains of a tropical storm that went inland over the west coast of Mexico, while low-level moisture moved northward and westward from the Gulf of California and the Gulf of Mexico. Rather substantial rainfall totals accompanied by unusually low temperatures were observed in the Rio Grande Valley and Southern Great Plains (figs. 8B, 8C).

The western portion of the front in advance of the record-breaking cool Canadian High established a zone

of lifting and convergence in the long fetch of moist air from the south and produced a flash-flood disaster in the Black Hills of South Dakota. Orographic influences and light winds aloft near the 700-mb ridge concentrated the full fury of the downpour within a relatively small area. Approximately 200 people lost their lives and about $100 million damage was done, mostly to buildings, roads, and bridges, as a result of rains amounting to as much as 7 in. in a few hours in some places.

June 12–18

The 700-mb circulation was quite flat over North America and the adjacent oceans with the result that the amplitude of the temperature anomaly pattern also decreased. The Great Basin and Northern Rocky Mountains were still the warmest regions, and the Great Lakes and Southeast remained cool, with greatest anomalies of warmth and coolness about 6° F (figs. 9A, 9B).

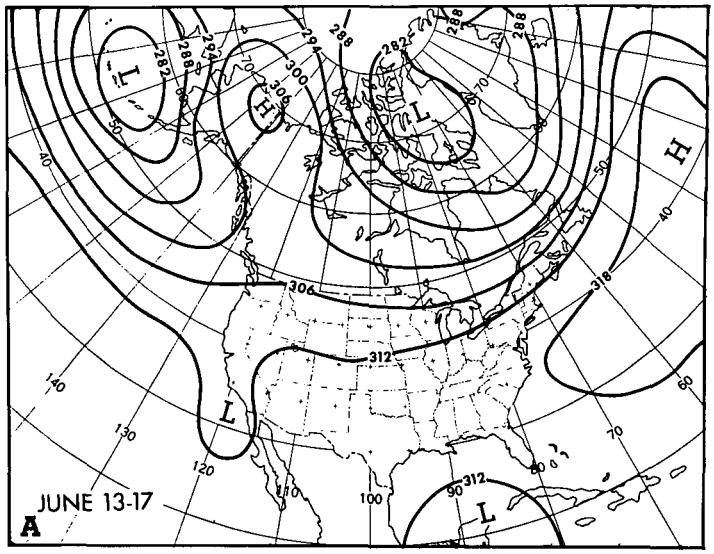
Precipitation was quite heavy and widespread over much of the country (fig. 9C), although much of the Southwest and a small portion of the Southeast were rainless. Severe thunderstorms struck many localities in the eastern and central portions of the Nation. Many people left their homes again in the Rapid City, S. Dak., area as 2–3 in. of rain fell in the vicinity and there was fear of another flash flood.

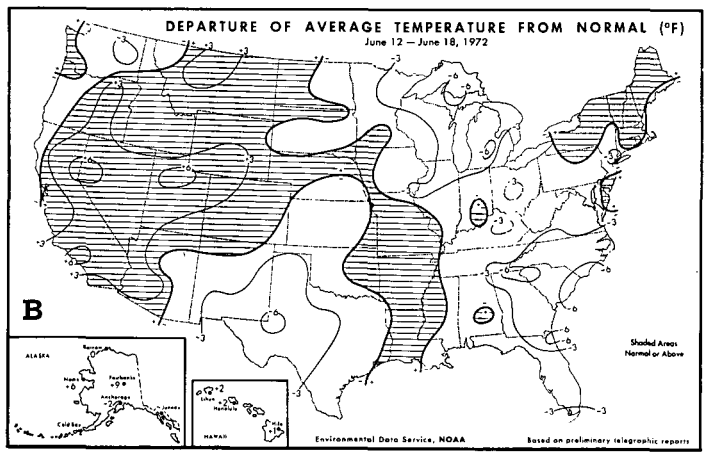
Heavy rain fell in southern Florida on the outskirts of hurricane Agnes, which had been slowly developing all week near the Yucatán Strait and had begun moving toward the Florida Panhandle over the weekend (figs. 9A, 9C).

June 19–25

The 700-mb circulation amplified again with a tendency toward blocking across southern Canada. A strong ridge built over the eastern Pacific, with downstream troughs near the United States west coast and the Appalachian Mountains and a ridge between them over the Great Plains. The ridge over the west-central Atlantic continued as it had all month (fig. 10A).

The outstanding weather event of the week and of the whole month was the torrential rain and extensive flooding caused by hurricane Agnes when she advanced along the Atlantic coast as a tropical storm after making landfall over northern Florida. The phenomenal rains of more than a foot that fell in parts of Virginia, Maryland, and Pennsylvania were due in part to the unusual track taken by Agnes. The tropical storm center interacted with and was finally absorbed by a deepening trough in the westerlies that slowed down and became cut off over the mid-Atlantic States for several days, thereby concentrating the rainfall of both a tropical and extratropical development over a relatively small area (figs. 10A, 10C). Rain averaging around 4 in. was beneficial over most of the Southeast, parts of which had been too dry, but from Virginia northward the ground was already well saturated due to previous wet weather (figs. 7C, 9C, and fig. 6 of Dickson 1972). The record 24-hr rainfall totals at Bridgeport, Conn., and Burlington,





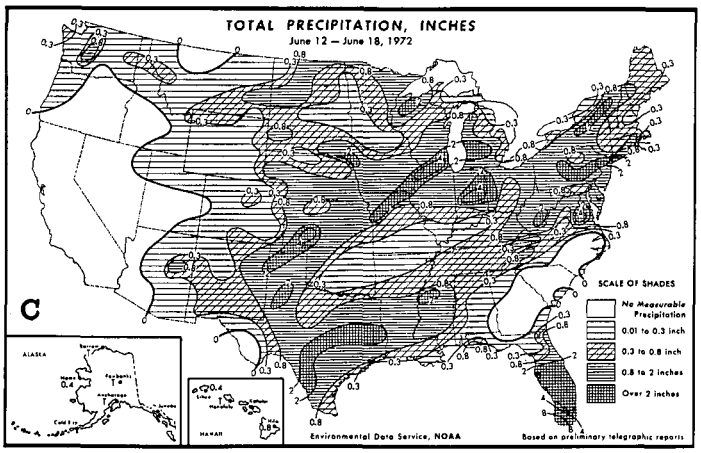
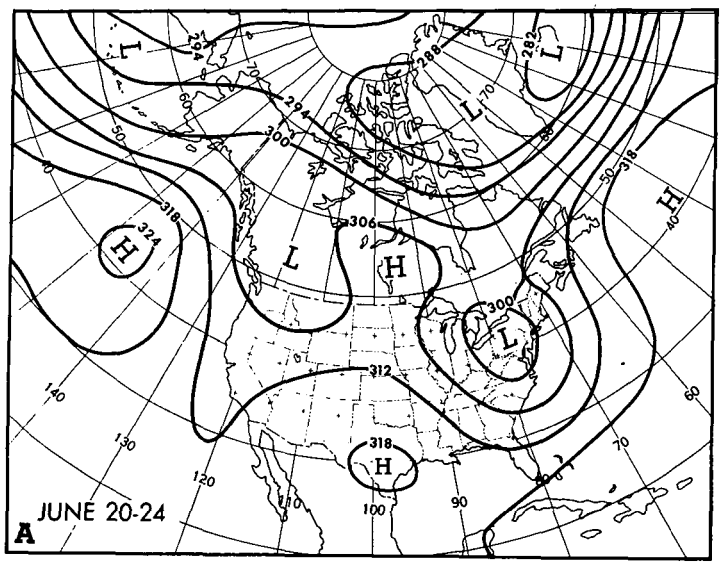
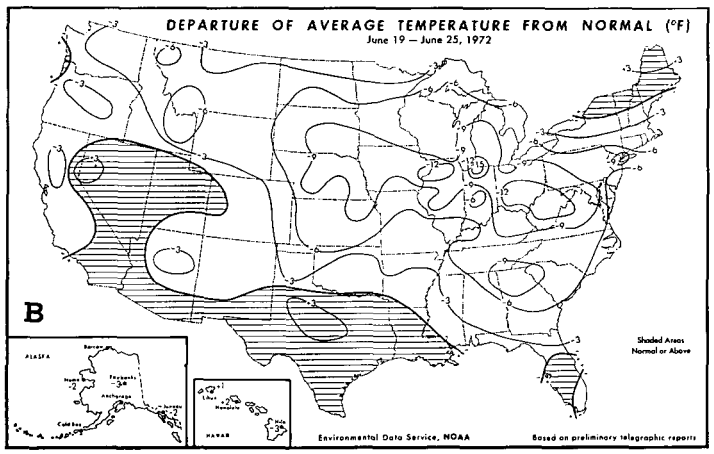


FIGURE 9.—Same as figure 7, (A) for June 13–17, 1972; (B) and (C) for week of June 12–18, 1972.

Vt., (table 2) did not occur with Agnes, but were observed several days before as a result of convective storms in the humid, tropical air mass.

The heaviest rains of Agnes were concentrated within a 24- to 48-hr period at most places, thereby leading to flash flooding of small streams, followed by extensive flooding of most major river basins as record and near-record crests moved downstream 3 or 4 days later. Although Dulles International Airport west of Washington, D.C., has too short a record for the establishment of climatologi-





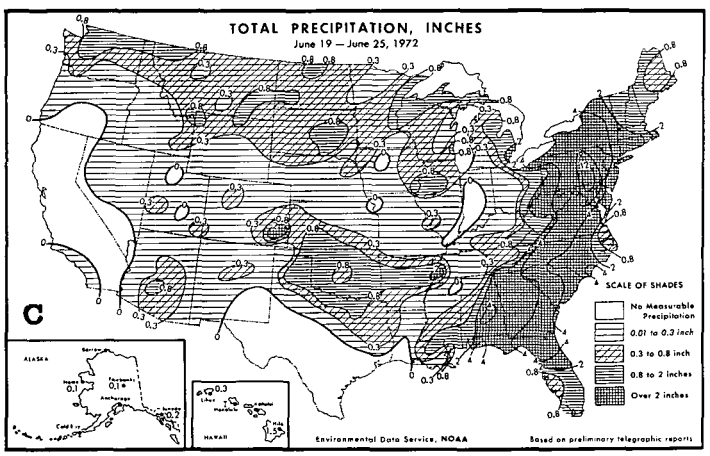
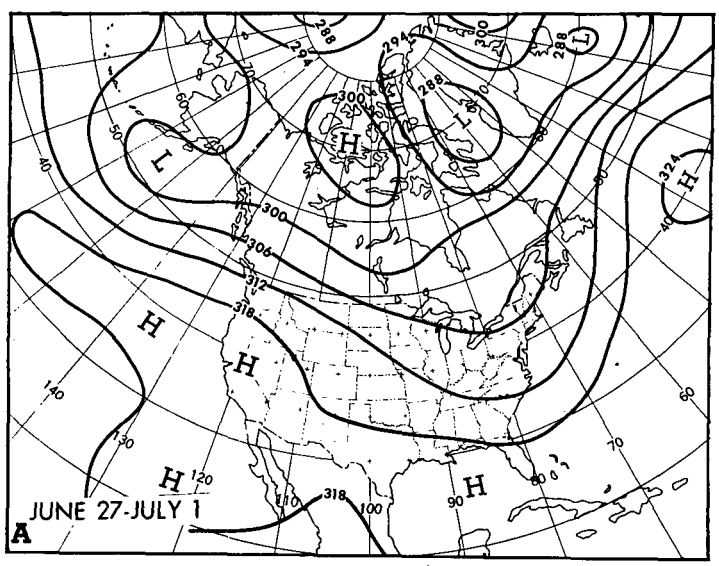
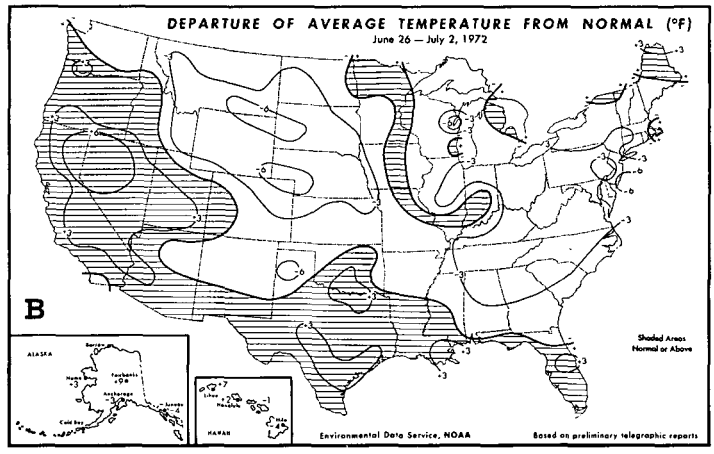


FIGURE 10.—Same as figure 7, (A) for June 20–24, 1972; (B) and (C) for week of June 19–25, 1972.





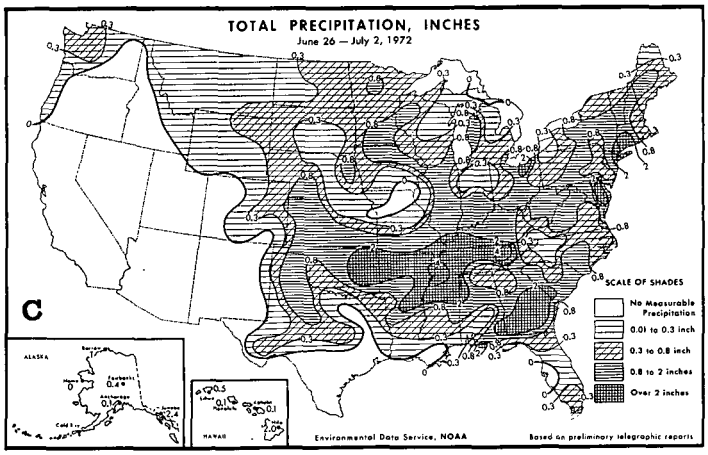


FIGURE 11.—Same as figure 7, (A) for June 27–July 1, 1972; (B) and (C) for week of June 26–July 2, 1972.

cal normals and extremes, the 11.88-in. rainfall within a 24-hr period and monthly total of 18.19 in. observed there will probably stand for many decades as record marks for heavy precipitation. The 12.55-in. rainfall within a *24-hr period* at Harrisburg, Pa., was in excess of the previous wettest *monthly* total of 10.67 in. observed in August 1933.

The long period of cloudiness and precipitation associated with Agnes, along the cool, Canadian air that came with the extratropical part of the storm, combined to produce rather low temperatures over most of the eastern two-thirds of the Nation. Temperatures averaged more than 12°F below normal for the week over portions of the Midwest and Central Appalachian Mountains (fig. 10B). The trough in the West and related precipitation kept most of that area on the cool side also. Only the central Great Basin and Southern Great Plains had average rainfall substantially above normal for the week.

June 26–July 2

The circulation deamplified again with blocking moving

northward, allowing the westerlies to increase over southern Canada and the United States (fig. 11A). A trough developed again in the Gulf of Alaska, forcing the ridge to the Pacific coast. The Great Plains ridge collapsed as the trough that had been near the Pacific coast the previous week advanced inland and combined with the eastern trough to make one broad, rather flat trough.

Temperatures rose again in the West under the influence of the ridging and remained quite high over Texas (fig. 11B). Most of the rest of the country remained on the cool side although the coolness was less extreme than during the previous week.

Precipitation was quite heavy near the boundary of the cool and warm air across the South (fig. 11C). Severe thunderstorms with wind gusts of hurricane force and large hail struck several places in Oklahoma and Missouri. Tornadoes also occurred in this and other areas, but did relatively minor damage. Most of the area west of the Continental Divide, except for the Pacific Northwest, was rainless.

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Dickson, Robert R., "Weather and Circulation of May 1972—Continued Drought in the Southwest," *Monthly Weather Review*, Vol. 100, No. 7, Aug. **1972**, pp. 648–652.

Environmental Data Service, NOAA, U.S. Department of Commerce and Statistical Reporting Service, U.S. Department of Agriculture, *Weekly Weather and Crop Bulletin*, Vol. 59, Nos. 23–28, June 5, 12, 19, and 26 and July 3 and 10, **1972**.